THERMAL CONDUCTIVITY OF ULTRANANOCRYSTALLINE DIAMOND FILMS

M.A.Angadi, J.A.Carlisle, O.Auciello, Xiancheng Xiao, James Birrell and J.A.Eastman

Materials Science Division, Argonne National Laboratory, Argonne IL 60439

Keywords: Diamond; Thermal Properties

Abstract

We report experimental results on the thermal transport properties of a series of ultrananocrystalline diamond (UNCD) films of varying thickness deposited on Si wafers. UNCD films were prepared by microwave plasma chemical vapor deposition using argon-rich Ar/CH_4 plasma chemistries, and consisting of 3-5 nm diamond grains separated by atomically abrupt grain boundaries containing a mixture of sp^3 and sp^2 bonding. The thermal conductivity at 310K was measured using the 3ω technique on UNCD films in thickness range 0.8-7.5μm. Typical values measured range from 1-12 W/mK, which is much less than for single crystal diamond, but larger than observed in previous studies with nanometer-scale grain size thin films. The thickness dependence of thermal conductivity can be explained on the basis of film microstructure and interfacial thermal resistance. A value of 3000MW/m^2-K was determined to be the lower limit of the interfacial thermal conductance of diamond at 310K. This value is more than an order-of-magnitude larger than reported values for any other grain boundary or heterophase system.